

AMENDMENTS

In the Specification:

Please amend the enumerated paragraphs of the specification as follows:

[0001] The invention relates to the field of polymer chemistry and, more specifically, to a catalyst for polymerizing alpha-olefins and a method for producing such a catalyst. In particular, a catalyst containing a ~~diamide~~ diamine compound is disclosed. The catalyst of the present invention is useful for producing linear low density copolymers of ethylene (LLDPE).

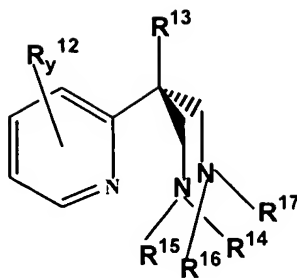
[0011] The catalyst component of the present invention is prepared by treating a magnesium halide composite support with a halogenized transition metal compound (e.g., MCl_4 , M includes Ti, Zr, Hf, V, Cr) and a chelating ~~diamide~~ diamine compound or its silylated derivative in the presence of organomagnesium as a promoting agent and halogenized silicon or boron compounds as activator thereof. The composite magnesium halide support is typically prepared by reacting metallic magnesium with (i) an alkyl halide or aromatic halide; (ii) a transition metal compound having the structural formula $M(OR)_aX_{4-a}$, wherein M is selected from the group consisting of Ti, Zr, Hf, V, and Cr; R is a C_{1-20} hydrocarbon, X is halogen, and a is an integer from 1 to 4; (iii) at least one electron donating compound containing at least one ether group; and (iv) at least one organo-silicon compound having at least one silicon-oxygen bond.

[0012] In the catalyst component of the present invention, a chelating ~~diamide~~ diamine compound or its silylated derivative are selected from compounds having the general structural Formula I:



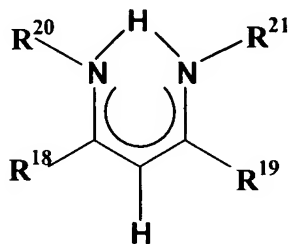
wherein R^1 , R^2 , R^3 and R^4 are independently hydrogen, C_{1-20} alkyl, C_{1-20} alkenyl, C_{1-20} alkylsilyl, C_{1-20} alkenylsilyl, aryl, arylsilyl, or halogenated derivatives of C_{1-20} alkyl, C_{1-20} alkenyl, C_{1-20} alkylsilyl, C_{1-20} alkenylsilyl, aryl, or arylsilyl; provided that at least both R^1 and R^3 are hydrogen, trimethylsilyl, or triethylsilyl group; R^5 is hydrogen or C_{1-20} hydrocarbon, and x is from 1 to 7;

~~diamide~~diamino-pyridene ligands of the Formula II:



wherein R^{12} is independently hydrogen or C_{1-20} alkyl, or two R^{12} groups may together form a ring, y is 1 or 2; R^{13} is hydrogen or C_{1-40} alkyl; R^{14} , R^{15} , R^{16} and R^{17} are independently hydrogen, C_{1-20} alkyl, C_{1-20} alkenyl, C_{1-20} alkylsilyl, C_{1-20} alkenylsilyl, aryl, arylsilyl, or halogenated derivatives of C_{1-20} alkyl, C_{1-20} alkenyl, C_{1-20} alkylsilyl, C_{1-20} alkenylsilyl, aryl, or arylsilyl; provided that at least both R^{14} and R^{16} are hydrogen atom or trimethylsilyl or triethylsilyl group; and

diketiminato ligands of Formula III:



wherein R^{18} and R^{19} are independently hydrogen, C_{1-20} hydrocarbon, or R^{18} and R^{19} groups may together form a ring; R^{20} and R^{21} are independently hydrogen, C_{1-20} alkyl, C_{1-20} alkenyl, C_{1-20} alkylsilyl, C_{1-20} alkenylsilyl, aryl, arylsilyl, or halogenated derivatives of C_{1-20} alkyl, C_{1-20} alkenyl, C_{1-20} alkylsilyl, C_{1-20} alkenylsilyl, aryl, or arylsilyl.

[0014] One aspect of the present invention is a catalyst component useful with an advanced Ziegler-Natta system. The catalyst component is prepared in the presence of non-metallocene ligands and comprises Mg, a transition metal (M), a halogen, an alkoxy ligand, silicon, and a chelating diamide diamine ligand. The catalyst utilizing the present catalyst component produces polyethylene copolymer in an improved manner and is compatible with existing production processes such as slurry and gas-phase polymerization.

[0015] The catalyst component of the present invention is prepared by treating a magnesium halide composite support with a halogenized transition metal compound (e.g., MCl_4 , M includes

Ti, Zr, Hf, V, Cr) and a chelating ~~diamide~~ diamine compound or its silylated derivative in the presence of organo-magnesium as a promoting agent and halogenized silicon or boron compounds as activator thereof. An example of a suitable magnesium halide support is a composite support prepared by treating metallic magnesium with (i) an alkyl halide or aromatic halide; (ii) a transition metal compound having the structural formula $M(OR)_aX_{4-a}$, wherein M is selected from the group consisting of Ti, Zr, Hf, V, and Cr; R is a C_{1-20} hydrocarbon, X is halogen, and a is an integer from 1 to 4; (iii) at least one electron donating compound containing at least one ether group; and (iv) at least one organo-silicon compound having at least one silicon-oxygen bond.

[0016] Examples of suitable ~~diamides~~ diamines are ~~diamides~~ diamines selected from compounds having the general structural formula $R^1R^2N(CR^5_2)_xNR^3R^4$, ~~diamide~~diamino-pyridene ligands, and diketiminato ligands. Silylated derivatives of these compounds can also be used.

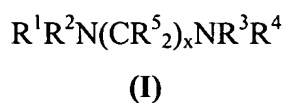
[0017] As an illustrative embodiment, a catalyst component according to the present invention is prepared by:

- (i) forming a slurry from metallic magnesium, iodine, alcohol, and either an alkyl or aromatic halide to form activated metallic magnesium, together with small content of organomagnesium compound having the formula $R'MgX$;
- (ii) contacting the slurry with a transition metal compound having the structural formula $M(OR)_aX_{4-a}$, an electron donor containing at least one ether group, and an organo-silicon compound having a Si--O bond;
- (iii) reacting the mixture from step (ii) with an alkyl or aromatic halide to form a magnesium-based support with excellent morphology, and flow ability;
- (iv) contacting the mixture from step (iii) with organomagnesium having the empirical formula $R'MgR''$, and then with a halogenized transition metal compound (e.g., MCl_4 , M includes Ti, Zr, Hf, V, Cr); and
- (v) reacting the mixture from step (iv) with a chelating ~~diamide~~ diamine compound or a silylated derivative in the presence of a halogenized silicon or boron compound as an activator.

[0032] **Promoting Agents and Activators.** The “support effect,” i.e., the lower activity observed for a catalyst when the catalyst is supported compared to an unsupported or homogeneous catalyst, is typically observed in either bulky ligand metallocene and metallocene-type catalysts, non-metallocene-type catalysts, other ‘single-site’ advanced catalysts, and even some Ziegler-Natta catalyst. This support effect contributes to the difficulty of commercializing new catalyst systems in currently existing production processes. To eliminate the support effect, one aspect of the present invention is a process of synthesizing a new Ziegler-Natta catalyst with a chelating ~~diamide~~ diamine and/or its silylated derivative by *in situ* reaction with Mg-based support in the presence of an activator and/or a promoting agent.

[0039] **Chelating ~~Diamides~~ Diamines and Silylated Derivatives thereof.** Chelating ~~diamide~~ diamine and its silylated derivatives react with a halogenated transition metal compound (e.g., MCl_4) to form catalytically active species for olefin polymerization. Examples of suitable halogenated transition metal compounds include $TiCl_4$, $ZrCl_4$, $HfCl_4$, $TiCl_4 \cdot 2THF$, $TiCl_3 \cdot 3THF$, $3TiCl_3 \cdot AlCl_3$, $CrCl_3 \cdot 3THF$, and VCl_5 . $TiCl_4$, $TiCl_4 \cdot 2THF$, $TiCl_3 \cdot 3THF$, $3TiCl_3 \cdot AlCl_3$, and $CrCl_3 \cdot 3THF$ are particularly suitable. The chelating ~~diamide~~ diamine/ MCl_4 ratio is typically about 0.01 to about 5.0; more typically about 0.50 to about 1.50.

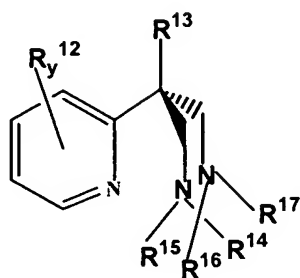
[0040] According to one embodiment, chelating ~~diamide~~ diamine compound and silylated derivatives thereof are those represented by the formula:



wherein R^1 , R^2 , R^3 and R^4 represent a hydrogen atom or an alkyl group of 1 to 20 carbon atoms such as methyl, ethyl, propyl, isopropyl, isobutyl, n-butyl, s-butyl, t-butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, dodecyl, hexadecyl, octadecyl, pentadecyl or cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl and cycloheptyl; a silicon-containing hydrocarbon group of 3 to 20 carbon atoms including alkylsilyl groups such as trimethylsilyl, triethylsilyl, isopropylsilyl, t-butylsilyl and arylsilyl groups such as phenyldimethylsilyl, diphenylmethylsilyl and alkenylsilyl groups such as allyldimethylsilyl; an alkenyl group of 2 to 20 carbon atoms such as vinyl, propenyl, oleyl or cyclohexenyl; an aryl groups having 6 to 20 carbon atoms such as phenyl, 2-tolyl, 3-tolyl, 4-tolyl, 2,3-xylyl, 2,4-xylyl, 2,5-xylyl, 2,6-xylyl, 3,4-xylyl, 3,5-xylyl, 2,6-dimethylphenyl, 2,6-di(isopropyl)phenyl, 2,6-di(s-butyl)phenyl, 2,6-di(t-butyl)phenyl, 2,3,4-

trimethylphenyl, 2,3,5-trimethylphenyl, 2,3,6-trimethylphenyl, 2,4,6-trimethylphenyl, 3,4,5-trimethylphenyl, 2,3,4,5-tetramethylphenyl, 2,3,4,6-tetramethylphenyl, 2,3,5,6-tetramethylphenyl, pentamethylphenyl, ethylphenyl, n-propylphenyl, i-propylphenyl, n-butylphenyl, sec-butylphenyl, tert-butylphenyl, n-pentylphenyl, neopentylphenyl, n-hexylphenyl, n-octylphenyl, n-decylphenyl, n-dodecylphenyl, n-tetra-decylphenyl, naphthyl and anthracenyl; an aralkyl group of 7 to 20 carbon atoms such as benzyl, (2-methylphenyl)methyl, (3-methylphenyl)methyl, (4-methylphenyl)methyl, (2,3-dimethylphenyl)methyl, (2,4-dimethylphenyl)methyl, (2,5-dimethylphenyl)methyl, (2,6-dimethylphenyl)methyl, (3,4-dimethylphenyl)methyl, (3,5-dimethylphenyl)methyl, (2,3,4-trimethylphenyl)methyl, (2,3,5-trimethylphenyl)methyl, (2,3,6-trimethylphenyl)methyl, (3,4,5-trimethylphenyl)methyl, (2,4,6-trimethylphenyl)methyl, (2,3,4,5-tetra-methylphenyl)methyl, (2,3,4,6-tetramethylphenyl)methyl, (2,3,5,6-tetramethylphenyl)methyl, (pentamethylphenyl)methyl, (ethylphenyl)methyl, (n-propylphenyl)methyl, (i-propylphenyl)methyl, (n-butylphenyl)methyl, (sec-butylphenyl)methyl, (tert-butylphenyl)methyl, (n-pentylphenyl)methyl, (neopentylphenyl)methyl, (n-hexylphenyl)methyl, (n-octylphenyl)methyl, (n-decylphenyl)methyl, (n-tetradecylphenyl)methyl, naphthylmethyl and anthracenylmethyl, each of which may be the same or different provided that at least both R^1 and R^3 are hydrogen atoms or trimethylsilyl or triethylsilyl groups; R^5 are independently a hydrogen atom or a hydrocarbon atom having 1 to 20 carbon atoms as mentioned above for $R^1 - R^4$, and x is 1 to 7.

[0041] Other suitable chelating ~~diamide~~ diamine compounds include ~~diamide~~diamino-pyridine ligands represented by the following formula:

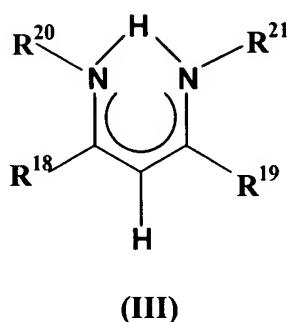


(II)

wherein R^{12} represents a hydrogen atom or a hydrocarbon atom having 1 to 20 carbon atoms, as mentioned above for $R^1 - R^4$ in the (I) structure, and each R^{12} may be the same or different, or the 2 R^{12} groups may together form a ring; y is 1 or 2; R^{13} represents a hydrogen atom or a

hydrocarbon atom having 1 to 20 carbon atoms as mentioned above for $R^1 - R^4$ in the (I) structure, and each may be the same or different; R^{14} , R^{15} , R^{16} and R^{17} are hydrogen, a hydrocarbon having 1 to 20 carbon atoms, or a silicon-containing hydrocarbon group of 1 to 20 carbon atoms as mentioned above for $R^7 - R^{10}$ in the (I) structure, and each of which may be the same or different provided that at least both R^{14} and R^{16} are hydrogen, trimethylsilyl, or triethylsilyl.

[0042] Other suitable chelating ~~diamide~~ diamine compounds include β -diketiminato ligands represented by the following formula:



wherein R^{18} and R^{19} are hydrogen or hydrocarbon having 1 to 20 carbon atoms as mentioned above for $R^7 - R^{10}$ in the (I) structure, and each may be the same or different; or the R^{18} and R^{19} may together form a ring; R^{20} and R^{21} are independently hydrogen or hydrocarbon having 1 to 20 carbon atoms or a silicon-containing hydrocarbon group of 1 to 20 carbon atoms as mentioned above for $R^7 - R^{10}$ in the (I) structure, and each may be the same or different.

[0057] The solid catalyst composition, and properties of polymers in the examples were measured according to the methods described herein. Composition analyses were conducted by ICP emission analysis method to determine Ti, Si, Mg, and Cl content in the solid catalyst component; alkoxy group and ~~diamide~~ diamine groups were tested by an internal standard gas chromatography (GC). After decomposing a solid component with water or acidic water to obtain a liquid sample, an amount of the an alcohol corresponding to the alkoxy group and diamine corresponding to the ~~diamide~~ diamine group in the obtained liquid sample were measured by GC, followed by converting into the content of alkoxy group and ~~diamide~~ diamine group. Melt flow index (MI) of polymers was measured at 190 °C, according to ASTM D1238. Melt flow ratio (MFR), which is the ratio of high melt flow index (HLMI or I_{21}) to melt index (I_2), was used as a measure of melt fluidity and a measure of the molecular weight distribution of

polymer. The melt flow ratio is believed to be an indication of the molecular weight distribution of the polymer; the higher the value, the broader the molecular weight distribution. Density was measured according to ASTM D 1505-98. Molecular weights and molecular weight distributions of polymers were also determined by gel permeation chromatography (GPC) against a polyethylene standard. Thermal analysis (TA) was used to measure the melting point and ΔH of polymers. The content of xylene soluble fraction at room temperature, %CXS, of the polymer was determined by dissolving 2 g of polymer in 200 ml of xylene at 135 °C, cooling in a constant temperature bath at 25 °C, and filtering through fast filter paper. An aliquot of the filtrate was evaporated to dryness, the residue weighed and the weight % soluble fraction calculated.

[0059] **Step (b).** A 250 ml three-necked flask, equipped with a stirrer, a reflux condenser and an addition funnel, was purged with nitrogen. To this reactor was added 100 ml of xylene, 10.0 g of The solid component prepared in step (a) and 17.5 g (33.3 mmol) of N,N'-di(2,6-diisopropylphenyl)-N,N'-di(trimethylsilyl)-1,2-ethane-diamine. The resulting mixture was heated to 80 °C for 30 minutes. Dibutylmagnesium (6.00 mmol) was added to this slurry over 30 minutes. After treatment at 80 °C for 2 hours, silicon tetrachloride (3.73 ml, 32.6 mmol) and titanium (IV) chloride (3.66 ml, 33.3 mmol) were successively added to the reaction mixture for 30 min. The mixture was refluxed in xylene for 6 hours. The resulting deep brown solution was completely precipitated by adding hexanes. The precipitate was filtered, washed with toluene/hexanes 3 times at 65 °C, and then washed with hexanes another 3 times, and dried by using hot nitrogen. The composition of the resulting solid catalyst component was $\text{Mg}_{12.1}\text{TiCl}_{27.4}(\text{OR})_{0.5}\text{Si}_{0.2}[\text{diamidediamine}]_{1.5}$. Ti content in the solid catalyst is 5.8 wt%.

[0068] The co-catalysts triisobutylaluminum (TIBA), trimethylaluminum (TMA), tri(n-octyl)aluminum (TnOA), and MAO were tested with a catalyst precursor of the invention and compared to result in catalysis in which the co-catalyst was triethylaluminum (TEA), as shown in Table 1. The data clearly show that the catalyst system in the present invention, activated with either trialkylaluminum (such as TIBA, TnOA, and TEA), TMA, or MAO has good catalytic performance regarding to activity, molecular weight distribution, co-monomer incorporation. The activity is comparable to current catalyst system in the commercial LLDPE process.

Table 1. Comparison of Co-catalysts with Catalyst Precursor of the Invention^a

Examples	Co-catalyst	Productivity	MI (I ₂)	MFR (I ₂₁ /I ₂)	Density (g/cm ³)	T _m (°C)	ΔH (g/J)
2	TEA	4800	1.294	27.02	0.9153	123.1	81.1
3	TMA	6300	1.150	26.58	0.9083	122.2	69.4
4	TIBA	4200	1.052	27.27	0.9171	124.0	93.2
5	TnOA	3800	1.297	27.31	0.9182	124.5	86.3
6	MAO	6000	1.286	24.22	<0.900	121.0	57.2
Comparative example 4	TMA ^c	2800	1.194	29.12	0.9292	126.7	133.8
Comparative example 5	TMA ^{b,c}	3440	0.983	29.01	0.9210	124.8	114.5

^aPolymerization Conditions: *see* Example 1 (3). Catalyst precursor is 50 mg. [1-Hexene]=100 ml, Productivity is given in units of gram polymer/gram catalyst-h-100 psi ethylene.

^bAmount of catalyst precursor is 100 mg.

^ccatalyst precursor without ~~diamide~~ diamine

[0069] Solid catalyst components (or precursors) were prepared in the same manner as in Example 1, except that N,N'-di(2,6-diisopropylphenyl)-N,N'-di(tri-methyl-silyl)-α,α'-xylenediamine, N,N'-di(2,6-diisoprocyclohexyl)-N,N'-di(trimethylsilyl)-9,10-phenanthrene-diamine, N,N'-di(2,6-diisopropylphenyl)-2-methyl-2-(2-pyridine)-propane-diamine (~~diamide~~ diamino-pyridine), and 2-((2,6-diisopropylphenyl)amino)-4-((2,6-diisopropylphenyl)amino)-2-pentene (β-diketimide) were used. The composition of the resulting solid catalyst components was Mg_{12.5}TiCl_{26.5}(OR)_{0.4}Si_{0.2}[~~diamide~~ diamine]_{1.3}, Mg_{14.1}TiCl_{27.6}(OR)_{0.3}Si_{0.2}[~~diamide~~ diamine]_{1.4}, Mg_{12.6}TiCl_{27.1}(OR)_{0.2}Si_{0.2}[~~diamide~~ diamine]_{1.2}, and Mg_{12.8}TiCl_{26.2}(OR)_{0.2}Si_{0.2}[~~diamide~~ diamine]_{1.3}, respectively. Ti content in the solid catalysts was about 7.0 wt%.

[0070] The co-polymerization was carried out in the same manner as in Example 1. The data show that ~~diamide~~ diamine-based catalysts have a narrower molecular weight distribution and better co-monomer incorporation compared to those of the control as evident from their much lower MFR, much lower density and melting point and/or ΔH values. In addition, the low molecular weight component in the catalyst of the present invention is much less than that of the catalytic compositions free of the silylated chelating diamine compound or a chelating diamine or its derivative. Of all chelating ~~diamide~~ diamine compounds, chelating ~~diamide~~ diamine containing the general structural formula of R¹R²N(CR⁵)_xNR³R⁴ (I), and β-diketiminato ligand

(III) show the best results when activating with an organo-aluminum co-catalyst. The Ziegler-Natta catalyst with ~~diamide~~diamino-pyridine ligand (II) show second best results.

Table 2. Comparison of Co-catalysts with Catalyst Precursor of the Invention^a

Examples	Diamide <u>Diamine</u>	Product.	MI (I ₂)	MFR (I ₂₁ /I ₂)	Density (g/cm ³)	T _m (°C)	ΔH (g/J)	CXS (Wt%)
7	None	2800	1.094	28.92	0.9307	128.6	165.7	25.2
8	None ^b	3200	0.998	28.90	0.9194	124.7	108.4	29.8
9	N,N'-di(2,6-diisopropylphenyl)-N,N'-di(trimethylsilyl)-1,2-ethane-diamine	4000	1.194	25.42	0.9039	123.0	69.4	9.6
10	N,N'-di(2,6-diisopropylphenyl)-N,N'-di(trimethylsilyl)-α,α'-xylene-diamine	4000	1.090	26.12	< 0.900	122.4	56.3	7.2
11	N,N'-di(2,6-diisoprocyclohexyl)-N,N'-di(trimethylsilyl)-9,10-phenanthrenediamine	2200	1.152	26.58	0.9083	123.2	74.8	10.2
12	N,N'-di(2,6-diisopropylphenyl)-2-methyl-2-(2-pyridine)-propane-diamine	3000	0.982	25.27	0.9140	124.0	94.2	14.2
13	2-((2,6-diisopropylphenyl)amino)-4-((2,6-diisopropylphenyl)amino)-2-pentene	4100	1.197	25.71	< 0.900	122.5	67.4	7.5

^aPolymerization Conditions: *see* Example 1, and amount of catalyst precursor is 50 mg. [1-Hexene]=100 ml, Productivity is given in units of gram polymer/gram catalyst-h-100 psi ethylene.

^bAmount of catalyst precursor is 100 mg.

[0077] Particularly disclosed is a catalyst component useful for the co-polymerization of ethylene and an alpha-olefin, wherein the catalyst component is prepared by: (i) providing a magnesium halide composite support by treating metallic magnesium with an alkyl halide or aromatic halide, a transition metal compound having the structural formula M(OR)_aX_{4-a}, at least one electron donating compound containing at least one ether group, and at least one organo-

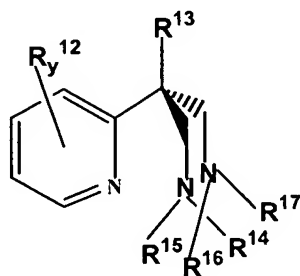
silicon compound having at least one silicon-oxygen bond; wherein M is selected from the group consisting of Ti, Zr, Hf, V, and Cr; R is a C₁₋₂₀ hydrocarbon, X is halogen, and a is 1 to 4; and (ii) treating the magnesium halide composite support with a halogenized transition metal compound and a chelating ~~diamide~~ diamine compound in the presence of one or more compounds selected from the group consisting of organo-magnesium compounds, halogenized silicon compounds, and halogenized boron compounds.

[0079] According to one embodiment, the chelating ~~diamide~~ diamine compound has the formula:



wherein R¹, R², R³ and R⁴ are independently hydrogen, C₁₋₂₀ alkyl, C₁₋₂₀ alkenyl, C₁₋₂₀ alkylsilyl, C₁₋₂₀ alkenylsilyl, aryl, arylsilyl, or halogenated derivatives of C₁₋₂₀ alkyl, C₁₋₂₀ alkenyl, C₁₋₂₀ alkylsilyl, C₁₋₂₀ alkenylsilyl, aryl, or arylsilyl; provided that at least both R¹ and R³ are hydrogen, trimethylsilyl, or triethylsilyl group; R⁵ is hydrogen or C₁₋₂₀ hydrocarbon, and x is from 1 to 7.

[0080] Alternatively, the chelating ~~diamide~~ diamine compound has the formula:



(II)

wherein R¹² is independently hydrogen or C₁₋₂₀ alkyl, or two R¹² groups may together form a ring, y is 1 or 2; R¹³ is hydrogen or C₁₋₄₀ alkyl; R¹⁴, R¹⁵, R¹⁶ and R¹⁷ are independently hydrogen, C₁₋₂₀ alkyl, C₁₋₂₀ alkenyl, C₁₋₂₀ alkylsilyl, C₁₋₂₀ alkenylsilyl, aryl, arylsilyl, or halogenated derivatives of C₁₋₂₀ alkyl, C₁₋₂₀ alkenyl, C₁₋₂₀ alkylsilyl, C₁₋₂₀ alkenylsilyl, aryl, or arylsilyl; provided that at least both R¹⁴ and R¹⁶ are hydrogen atom or trimethylsilyl or triethylsilyl group.

[0082] Step (ii) can ~~further~~ comprise treating the magnesium halide composite support with a halogenated transition metal compound of the formula m(M¹X¹_a)·n(M²X²_b)·o(THF), wherein M¹ and M² are independently selected from the group consisting of Ti, Zr, Hf, Al, V, Al, and Cr; X¹ and X² are halogen; a and b are independently 2 to 5; and m, n, and o are independently 0 to 4.

According to one embodiment, the halogenated transition metal compound is selected from the group consisting of TiCl_4 , ZrCl_4 , HfCl_4 , $\text{TiCl}_4 \cdot 2\text{THF}$, $\text{TiCl}_3 \cdot 3\text{THF}$, $3\text{TiCl}_3 \cdot \text{AlCl}_3$, $\text{CrCl}_3 \cdot 3\text{THF}$, and $\text{VCl}_5 \cdot \text{TiCl}_4$, $\text{TiCl}_4 \cdot 2\text{THF}$, $\text{TiCl}_3 \cdot 3\text{THF}$, $3\text{TiCl}_3 \cdot \text{AlCl}_3$, and $\text{CrCl}_3 \cdot 3\text{THF}$.

[0083] Step (ii) can further comprise treating the magnesium halide composite support with an organo-magnesium compound having the formula $\text{R}'\text{MgR}''$, wherein R' and R'' are independently C_{2-12} alkyl groups.

[0084] Step (ii) can also comprise treating the magnesium halide composite support with a compound having the formula $\text{MR}_{m-a}\text{X}_a$, wherein M is a Group 13 or Group 14 element, R is a C_1 -20 hydrocarbon, X is halogen, m is a number equal to the valence of M, and a is 1 to m.

[0087] A solid catalyst component useful for the (co)-polymerization of olefins is disclosed. The catalyst component is prepared by reacting an activated magnesium halide composite support with a halogenized transition metal compound and a chelating ~~diamide~~ diamine compound in the presence of organo-magnesium as a promoting agent and halogenized silicon or boron compounds as an activator. The catalyst component can be used with an organo-aluminum compound to provide a solid catalyst system that is compatible with slurry and gas phase polymerization processes. Linear low density polyethylene (LLDPE) produced using the catalyst component of the present invention displays a low molecular weight distribution, improved comonomer incorporation, low content of the low molecular weight component, and excellent morphological properties such as spherical shape and high bulk density.